

CLAIMS

1. A display apparatus capable of detecting that a predetermined place of a display screen has been pointed by a human hand or a pointing member, the display apparatus comprising:

display elements formed near intersections of signal lines and scanning lines respectively arranged in vertical and horizontal directions;

image pickup units provided so as to be respectively associated with the display elements, which pick up incident light in a predetermined range in a state in which a predetermined display image is displayed on the display screen by the display elements; and

a pointer detection portion which detects a portion having high correlation with a display image at image pickup time from the picked-up image, as a position pointed by a hand or a pointing member on the display screen.

2. The display apparatus according to claim 1, wherein
the display elements display two types of display images having high image picked-up contrast by staggering times; and
when each of the two types of display images is displayed, the image pickup units perform image pickup separately from each other.

3. The display apparatus according to claim 2, wherein the two types of display images are display images having a great display luminance difference from each other.

4. The display apparatus according to claim 3, wherein one of the two types of display images is a display image in a state in which back light is turned off.

5. The display apparatus according to claim 3, comprising:
a display control circuit which conducts phase detection

by alternately conducting image pickup in a high display luminance state and image pickup in a low display luminance state at a predetermined interval.

6. The display apparatus according to claim 2, wherein the two types of display images are a display image containing a color for which the image pickup units have a high sensitivity and a display image containing a color for which the image pickup units have a low sensitivity.

7. The display apparatus according to claim 2, wherein the display elements change over the two types of display images at an interval that makes it possible for a human to recognize that the screen is blinking.

8. The display apparatus according to claim 1, wherein the two types of display images are images each having a pattern obtained by combining at least two types of colors in a predetermined pitch and a predetermined ratio.

9. The display apparatus according to claim 1, wherein the pattern includes two colors having a high image pickup contrast ratio.

10. The display apparatus according to claim 9, wherein in an area of display of the two types of colors, the area of a color for which the image pickup units have a high sensitivity is larger than that of the other color.

11. The display apparatus according to claim 8, wherein a minimum line segment of the pattern is at least a minimum interval between the image pickup units and the pointed position.

12. The display apparatus according to claim 1, wherein the display elements display display images having a

plurality of types of forms at the image pickup time,

the image pickup units perform image pickup with respect to the display images in the display forms, and

the pointer detection portion detects a portion having high correlation in the picked-up images in all of the display forms, as the pointed position.

13. The display apparatus according to claim 1, wherein

an image pickup frame interval is provided between consecutive display frame intervals,

the display elements perform display corresponding to the display frame interval and display corresponding to the image pickup frame interval, and

the image pickup units perform image pickup processing during only the image pickup frame interval.

14. The display apparatus according to claim 13, wherein when changing over from display in the display frame interval to display in the image pickup frame interval, the display elements perform display corresponding to a dummy frame for compensating response of the display elements.

15. The display apparatus according to claim 1, comprising:

a pointing image generation portion which generates a pointing image to indicate a place to be pointed by a hand or a pointing member,

wherein the display elements display the pointing image on the screen.

16. The display apparatus according to claim 1, comprising:

a first substrate having the image pickup units and the display elements; and

a second substrate disposed to be opposed to the first substrate,

wherein the first substrate is disposed on an observer's side as compared with the second substrate.

17. An information terminal apparatus including a display apparatus which incorporates image pickup sensors, the information terminal apparatus comprising:

a portable strap having a surface form which can be recognized in a picked-up image of the image pickup sensors, the portable strap being formed of a soft material which expands in contact area when pressed against a display screen; and

a position detection portion which detects a position in which the strap is pressed, on the basis of a picked-up image obtained from the image pickup sensors when the strap is pressed against an arbitrary position of the display screen.

18. The information terminal apparatus according to claim 17, wherein the soft material has a reflectance of at least 50% and the soft material is a material which increases in contact area when pressed against the display screen.

19. The information terminal apparatus according to claim 18, wherein the soft material has a pattern which can be read easily by the image pickup sensors, on its surface.

20. The information terminal apparatus according to claim 18, wherein the soft material has a light source for projecting a pattern which can be read easily by the image pickup sensors into the display screen.

21. The information terminal apparatus according to claim 17, wherein the soft material is a transparent soft material which increases in contact area when pressed against the display screen and which has a mirrorlike surface to reflect light from the display apparatus therein.

22. A display apparatus capable of detecting that an arbitrary place of a display screen has been pointed by a human hand or

a pointing member, the display apparatus comprising:

display elements formed near intersections of signal lines and scanning lines respectively arranged in vertical and horizontal directions;

image pickup units which pick up incident light in a predetermined range;

D/A conversion circuits provided every a plurality of signal lines to supply pixel data for display to a plurality of signal lines associated therewith;

amplifier circuits which output the picked-up image data in the image pickup units from pixels by using signal lines that are not supplied with pixel data, while the D/A conversion circuits supply pixel data to signal lines in order; and

a pointer detection portion which detects a position pointed by a hand or a pointing member on the display screen, on the basis of the picked-up image data.

23. The display apparatus according to claim 22, wherein the pointer detection portion detects the pointed position on the basis of the picked-up image data in pixels connected to one signal line among a plurality of signal lines supplied with pixel data by the D/A conversion circuits.

24. The display apparatus according to claim 22, wherein the pointer detection portion detects the pointed position on the basis of the picked-up image data in pixels connected to one scanning line among a plurality of adjacent scanning lines.

25. The display apparatus according to claim 22, wherein whenever the image pickup units perform image pickup, the pointer detection portion detects an image that indicates a pointed position, and when a diameter of the image is maximized, the pointer detection portion judges that the display screen has been pressed strongly by a hand or a pointing member.

26. The display apparatus according to claim 22, wherein the pointer detection portion performs a plurality of product sum computations for successively adding image data of every scanning line, and a division computation conducted using a result of the product sum computations as a numerator or a denominator.

27. The display apparatus according to claim 26, comprising:
a first computation circuit formed on the substrate on which the display elements are formed to conduct the product sum computations; and

a second computation circuit formed on a semiconductor substrate different from the substrate on which the display elements are formed to conduct the division computation.

28. The display apparatus according to claim 22, wherein
denoting the number of pixels in a signal line direction of the display screen by X, the number of pixels in a scanning line direction by Y, and the picked-up image data in an arbitrary pixel (x, y) (where $0 \leq x \leq X$ and $0 \leq y \leq Y$) by L(x, y),

the pointer detection portion obtains central coordinates (Ex, Ey) of the hand or pointing member using expression (17), and obtains widths (Vx, Vy) of the hand or pointing member in the x direction and y direction using expression (18).

$$Ex = \frac{\sum_{y=0}^{239} \sum_{x=0}^{319} xL(x, y)}{\sum_{y=0}^{239} \sum_{x=0}^{319} L(x, y)} \quad Ey = \frac{\sum_{y=0}^{239} \sum_{x=0}^{319} yL(x, y)}{\sum_{y=0}^{239} \sum_{x=0}^{319} L(x, y)} \quad (17)$$

$$Vx = \frac{\sum_{y=0}^{239} \sum_{x=0}^{319} (x - Ex)^2 L(x, y)}{\sum_{y=0}^{239} \sum_{x=0}^{319} L(x, y)} \quad Vy = \frac{\sum_{y=0}^{239} \sum_{x=0}^{319} (y - Ey)^2 L(x, y)}{\sum_{y=0}^{239} \sum_{x=0}^{319} L(x, y)} \quad (18)$$

29. The display apparatus according to claim 28, wherein the

picked-up image data is a picked-up image subjected to image processing.

30. A display apparatus capable of detecting that an arbitrary place of a display screen has been pointed by a human hand or a pointing member, the display apparatus comprising:

- display elements formed near intersections of signal lines and scanning lines respectively arranged in vertical and horizontal directions;

- image pickup units which pick up incident light in a predetermined range;

- binary data storage units which store binary data corresponding to an image picked up by the image pickup units; and

- a pointer detection portion which detects a position pointed on the display screen by the hand or pointing member, on the basis of a place where the binary data changes in logic and ambient brightness.